

Observation of the Glochidium, Metamorphosis, and Juvenile of *Anodonta californiensis* Lea, 1857

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(1 Plate; 1 Text figure)

Anodonta californiensis Lea, 1857, is a bivalve inhabitant of freshwater ponds with muddy bottom substrates and lotic conditions. The specimens used in this study of its larval and juvenile biology were collected from Santa Ana Creek, a tributary of the Pajaro River, near Hollister, California. The observations were carried out at San Jose State College.

The glochidia larvae of *Anodonta californiensis* possess teeth at each shell lip and a moderately long attachment thread. A single adductor muscle is also present. The 0.2 mm larvae proved surprisingly hardy. Glochidia maintained in un aerated, ice-bath cooled water at 15 to 16° C survived up to 36 hours. Infestation possibilities are surely enhanced by this long free-state viability of an eventual obligate parasite.

When these larvae become attached to gill arches and filaments, fins, or barbules of a host fish, a chemical action is initiated. The usual response of the host to the parasite is tissue proliferation at the attachment site. Rapid growth of tissue at the site covers the parasite and a cyst is formed around it.

Several mosquito fish, *Gambusia affinis* (Baird & Girard, 1839), were employed as artificial hosts in this study. LEFEVRE & CURTIS (1908) found the Anodontinae not very host-specific. They found North American species of the bivalve subfamily able to utilize as hosts any number of common fresh-water fish, including various bass, trout, many perch-like fishes, and some catfish. Artificial infestation of the mosquito fish was accomplished by maintaining them for several hours in vigorously aerated water suspending many glochidia removed from a live, gravid female clam. Permanent attachment areas on this host included the gills, opercular edge, and all fins. Encystment, measured from the time of attachment to cyst completion, required 3 to 4½ hours at 20° C.

The length of the parasitic period following excystment is variable, depending upon temperature. *Anodonta californiensis* remained encysted on *Gambusia affinis* for 26 to 27 days at an average temperature of 20° C. The excystment period for the juveniles ranged over two days, corresponding to the findings of LEFEVRE & CURTIS, 1908. They showed that spring infections from winter-breeding Unionids, including *Anodonta*, often result in narrow-span excystment periods.

Excystment marks the completion of a metamorphosis. The morphologically infective glochidium is transformed into an early juvenile clam, possessing some adult characteristics and organs. The structures evident at this stage include the paired, trilobed livers or "digestive glands;" two prominent adductor muscles; a mantle with a ciliated edge; a bilobed, ciliated foot possessing an adhesive structure (byssal gland); and one pair of gills. The siphons and immature gonads noted by various observers were not evident in the juvenile *Anodonta californiensis*. The glochidial shell teeth and attachment thread are lost during metamorphosis. The byssal gland is lost early in adult life. HOWARD (1914: 46) mentions that the outer gills in *Anodonta* are not acquired until the second year of growth. This latter set of gills is important in the Anodontinae as female marsupia, holding many developing glochidia during reproduction. The long marginal shell hinge of the glochidium becomes more apical and concentrated in the early juvenile (Figure 1 and Figure 2).

Behavior and growth of the juvenile stage was noted upon excystment. The foot of the young clam was long and ciliated. The foot could be extended more than twice the length of the clam shell. When the foot was extended, the antero-apical cilia began to beat. The ciliary activity ceased when the foot attached to the substrate. Rapid contraction of the foot after attachment caused the body

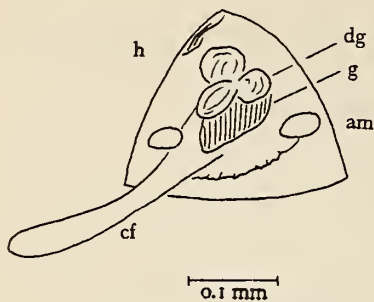


Figure 1

Early excysted juvenile - longitudinal view with left valve removed
 h - hinge; cf - ciliated foot; dg - digestive gland;
 g - gill; am - adductor muscle

mass to be pulled forward. The valves were maintained open at an angle of about 45° during movement, but could be closed quickly when the animal was disturbed or overturned; the small clam righted itself with the aid of the cylindrical, adhesive foot.

Juvenile growth studies revealed a very rapid rate. An average daily increase of 0.15 mm (long axis) amounted to an 840% increase in size over a 14 day period. This growth rate correlates with the results of HOWARD (1922: 69-70), investigating the growth rates of another Unionid, *Lampsilis luteola* Lamarck, 1819. The overall growth rates of the juveniles of both *Anodonta californiensis* and *L. luteola* were about 50 times that of the larger adults.

Following the discovery that the larval stages of many fresh-water clams are parasitic on fish, many attempts were made to raise adults in captivity. These efforts were directed toward providing a food source, shell material for the once active "pearl button" industry, and information concerning the effects of glochidia on the fresh-water

fisheries. No particular difficulty was experienced in carrying certain species through the parasitic stage, but few investigators were able to maintain the clams through the juvenile stage to reproductive or harvestable adulthood. Artificial propagation experiments, in which fish were mechanically infested with glochidia and released, appeared ineffective. Survival of the juveniles depended solely on the chance that the host fish would be over the proper habitat conditions at the time of excystment. Studies by ISELY (1911) and D'ELISCU (1970 MS) showed that few or no juveniles live in the observed adult habitat.

Juveniles were difficult to collect for many species, including *Anodonta californiensis*. The juveniles of some species possess byssal glands and inhabit loose gravel, while the adults live in deep mud or sand (HOWARD, 1914: 8). The morphology, physiology and difficulty of collection of the juvenile stage seem to indicate occupation of an entirely different habitat from that of the adult. This separation of different age groups may be similar to marine bivalve forms with motile larvae that do not compete directly with adults for food. Direct implantation of excysted Unionid juveniles into their specific habitat requirements would greatly facilitate increased production in terms of individual survival rates.

Literature Cited

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